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Genotypic and phenotypic characterisation of three local chicken ecotypes of Ghana based on principal component analysis and body measurements

Abstract

This study was to characterise three Ghanaian local chicken ecotypes, namely, Interior Savannah, Forest and Coastal Savannah ecotypes, based on morphological data and single nucleotide polymorphism (SNP) genotypes. Morphological data including shank length, body girth, back length, thigh length, beak length, comb length and wattle length were collected. Blood samples were also obtained for SNP genotyping with Affymetrix chicken 600k SNP chip. Principal component analysis showed that Forest and Coastal Savannah birds were closely related. Generally, all three ecotypes seemed very diverse especially birds from the Interior Savannah zone. Morphological characterisation showed ecotype, sex and pen had significant effect on body weights ($p < 0.05$). Very few of the phenotypes reported to be associated with heat resistance – frizzle (2%) and naked neck (1.6%) – were found in the current study. It is concluded that the three local ecotypes are genetically diverse but with similar morphological features.

Keywords

local chicken ecotypes, characterisation, SNPs, PCA

Disciplines

Genetics | Poultry or Avian Science

Comments

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Genotypic and phenotypic characterisation of three local chicken ecotypes of Ghana based on principal component analysis and body measurements

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Summary

This study was to characterise three Ghanaian local chicken ecotypes, namely, Interior Savannah, Forest and Coastal Savannah ecotypes, based on morphological data and single nucleotide polymorphism (SNP) genotypes. Morphological data including shank length, body girth, back length, thigh length, beak length, comb length and wattle length were collected. Blood samples were also obtained for SNP genotyping with Affymetrix chicken 600k SNP chip. Principal component analysis showed that Forest and Coastal Savannah birds were closely related. Generally, all three ecotypes seemed very diverse especially birds from the Interior Savannah zone. Morphological characterisation showed ecotype, sex and pen had significant effect on body weights ($p < 0.05$). Interior Savannah ecotypes were the heaviest ($p < 0.05$) with mean weights of 1.23 kg for females and 1.40 for males. Sex also had strong significant effects on most of the morphological measurements with no sex by ecotype interaction effect ($p > 0.05$). Very few of the phenotypes reported to be associated with heat resistance – frizzle (2%) and naked neck (1.6%) – were found in the current study. It is concluded that the three local ecotypes are genetically diverse but with similar morphological features.

Keywords: local chicken ecotypes, characterisation, SNPs, PCA

Introduction

Poultry play vital roles in developing countries by providing protein in the form of meat and eggs (Moula *et al.*, 2013) with few or no religious or cultural restrictions. Chickens are the lead poultry species worldwide (Dessie *et al.*, 2012) and provide affordable means of income to meet various subsistence needs including medical care and education for rural folk. In Africa, local chickens, also referred to as village or scavenging chickens, are the focus of many women and children as they are smaller in size and require very little feed and other management inputs to produce desirable outputs compared to exotic chicken (Osei-Amponsah *et al.*, 2015). Their unique taste and high cultural value contribute to the long list of attributes that make these birds the most preferred choice for backyard farming in many African countries. These birds are also

more disease resistant and hardy and hence have higher survival rate compared to exotic poultry (Msoffe, 2003; Fayeye *et al.*, 2006; Mahrous *et al.*, 2008). In Ghana, the value of local chicken to enhance malnutrition and aid in poverty alleviation has been well documented (Osei-Amponsah *et al.*, 2015).

Characterisation of local poultry species is limited but essential for conservation (Osei-Amponsah *et al.*, 2015; Brown *et al.*, 2017). Unfortunately, the general trend in developing countries, is to focus production policies on highly selected, higher performing, exotic breeds at the expense of local breeds, thus increasing the risk of loss of these indigenous animal genetic resources (Brown *et al.*, 2017). With the ever-increasing human population numbers and hence rising demand for highly nutritious food, emerging diseases and climate change, characterisation and conservation of animal genetic resources is critical. In Ghana, previous studies to characterise local chicken populations have been based on microsatellite markers (Osei-Amponsah *et al.*, 2010) and phenotypic and genetic parameters for production traits (Osei-Amponsah *et al.*, 2013) but these have been limited to two ecotypes (Interior Savannah and Forest). Kayang *et al.* (2015) expanded the study to three ecotypes (Interior Savannah, Forest and Coastal Savannah) using microsatellites and mitochondrial DNA analyses, but their work did not cover body measurements.

This study therefore employed morphological and SNP genotypes to characterise three local chicken ecotypes of Ghana, namely, Interior Savannah, Forest and Coastal Savannah ecotypes, as part of a great effort to genetically improve disease resistance to Newcastle disease in Africa (US Agency for International Development Feed the Future Innovation Lab for Genomics to Improve Poultry, <http://gip.ucdavis.edu>).

Material and Methods

Study location and experimental animals

Local chickens were sampled from three ecozones of Ghana, namely, Interior Savannah (IS), which comprises the Guinea Savannah and Sudan Savannah, Forest (FO) and Coastal Savannah (CS) zones (Figure 1). The birds were tagged and maintained at the Livestock and Poultry Research Centre (LIPREC), University of Ghana, Legon, Accra. They were grouped into 25 sire half-sib families per ecotype with a mating ratio of 1 male to 8 females and served as the breeding population used in the current study.

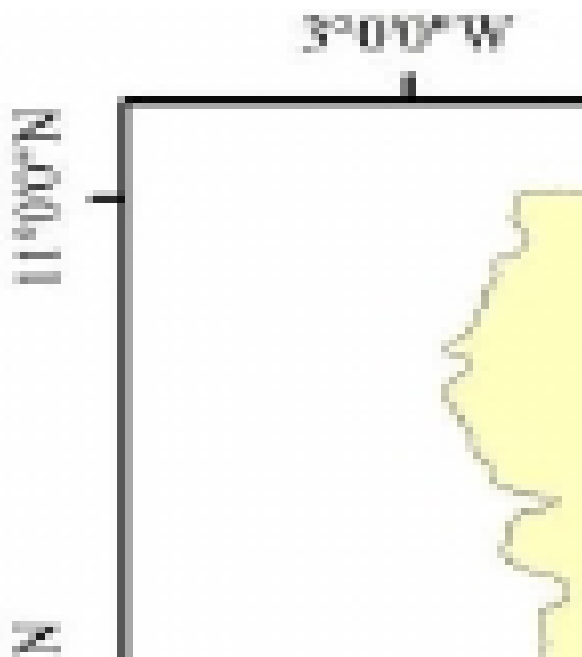


Figure 1: Agro-Ecological zones of Ghana
Source: Antwi *et al.* (2014)

Data collection and statistical analysis

Sex, body weights and body measurements were collected on a total of 250 offspring of the breeding population (IS= 56, FO= 139 and CS= 55) at 30 weeks old comprising 116 males and 134 females. The following linear body measurements were recorded using a measuring tape: shank length, body girth, back length, thigh length, beak length, comb length and wattle length. Phenotypes associated with heat loss including the naked neck, frizzle and rose comb were identified and recorded. Body weights were taken using a weighing scale. All morphological traits were analysed with linear models and corrected for the systematic effects. Least square means were then estimated per ecotype, and statistically analyzed for pairwise differences using the R version 3.3 software.

Genotypes were available on 1,444 descendants of the breeding stock (CS=513, FO=520, IS=411). After genotype cleaning, linkage analysis with an LD cut-off of 0.2 was performed. This resulted in a subset of 37,000 SNPs that were in linkage equilibrium. These SNPs were used in a principal component analysis (PCA) implemented with the “SNP-relate” package in R version 3.3.

Results and Discussion

Out of 250 birds used in this study, only 5 frizzle (2%) and 4 naked neck birds (1.6%) were found. All the birds had normal combs except four that had rose combs. Osei-Amponsah *et al.* (2010) and Brown *et al.* (2017) also reported low but slightly higher frequencies of these major genes. The low frequency of rose combs recorded, was attributed to the fact that they are an adaptation to reduce heat loss from the body during cold weather which is not the case in the

tropics. A similar trend was observed by Dahloun *et al.* (2016) in Algerian local chicken.

Least-square means (\pm SE) per ecotype for the eight morphological traits studied are presented in Table 1. Sex appeared to have a very strong significant effect on the body weight, thigh length, body girth, beak length, shank length and back length differences among the ecotypes ($p < 0.05$). However, there was no significant interaction effect between ecotype and sex for any of the traits measured ($p > 0.05$).

Significant differences between ecotypes were found for only body weight ($p < 0.05$). Interior Savannah birds were the heaviest with mean weights of 1.23 kg for females and 1.40 kg for males. Osei-Amponsah *et al.* (2010) also found higher body weights for Interior Savannah birds compared to the Forest ecotype.

Table 1: Least square means \pm SE for body weights (kg) and body measurements (cm) of Ghanaian local chicken ecotypes based on ecotype.

Trait	Coastal	Forest	Interior Savannah
	Savannah n= 55	n= 139	n= 56
Back Length	8.41 \pm 0.14 _a	8.80 \pm 0.09 _a	8.79 \pm 0.14 _a
Body Weight	1.20 \pm 0.03 _a	1.21 \pm 0.02 _a	1.30 \pm 0.03 _b
Shank Length	3.22 \pm 0.06 _a	3.23 \pm 0.04 _a	3.27 \pm 0.06 _a
Comb Length ¹	3.46 \pm 0.11 _a	3.44 \pm 0.07 _a	3.55 \pm 0.12 _a
Wattle Length ¹	1.61 \pm 0.08 _a	1.63 \pm 0.05 _a	1.76 \pm 0.10 _a
Thigh Length	6.23 \pm 0.10 _a	6.09 \pm 0.06 _a	6.00 \pm 0.10 _a
Body Girth	9.80 \pm 0.11 _a	9.67 \pm 0.07 _a	9.71 \pm 0.11 _a
Beak Length	1.28 \pm 0.03 _a	1.34 \pm 0.02 _a	1.35 \pm 0.03 _a

In the same row, means with subscripts in common are not significantly different $p < 0.05$

¹ Recorded for males only

A plot of the first two eigenvectors based on PCA analysis involving 32,000 SNPs is given in Figure 2. These eigenvectors together accounted for ~2.5% of the variation among the birds, indicating that the genetic variation in these local breeds is high.

Generally, Forest and Coastal Savannah birds seemed more closely related to each other than to the Interior Savannah birds. This could be attributed to the proximity and easy access routes between the two ecozones and thus gene flow between the two zones either through trade, rural urban drift or crossbreeding. This is in line with a similar study using microsatellite markers by Kayang *et al.* (2015) which also showed that local chickens from the Forest and Savannah Zones of Ghana were closely related and indicated that Savannah birds may have come from the forest zone. Sixteen (3.89 %) of the Interior Savannah birds were found within the Coastal Savannah and Forest cluster (Figure 1). This could be due to gene flow through trade and migration. About 8.46 % (44 birds) of the Forest ecotype clustered closely together, separate from the main group. These birds had a common sire and could be traced back to a farmer at Ejisu in the Ashanti Region.

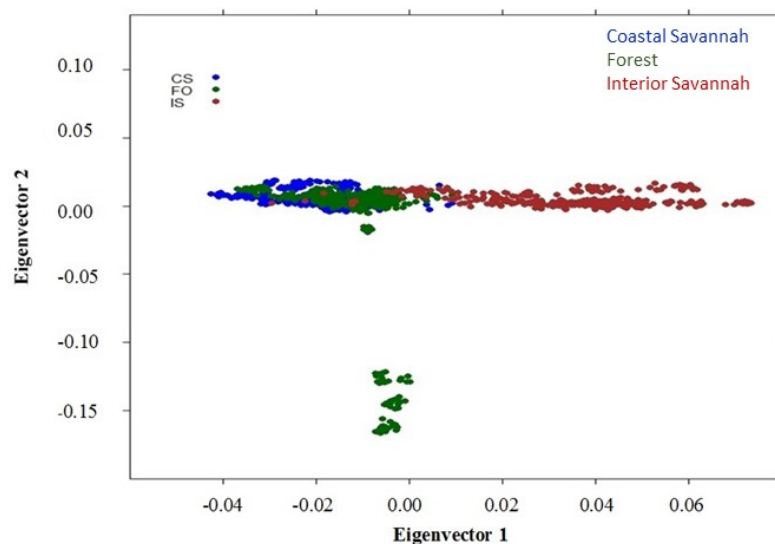


Figure 2: PCA Plot based on 32,000 SNPs.

The wide dispersion seen in Figure 2 shows that the local chicken population of Ghana is still genetically diverse, especially the birds from the Interior Savannah zone. The slight overlap between the Coastal Savannah and the Interior Savannah population confirms the South-North gene flow pattern postulated by Osei-Amponsah *et al.* (2010) and corroborated by Kayang *et al.* (2015). This situation, if not addressed, could result in the loss of diversity in the local chicken genetic resource in the Interior Savannah zone over time.

Conclusions

Local chickens possess a high potential for improving malnutrition and enhancing food security. Results from this study indicate that the three ecotypes are all similar morphologically. There is however very wide genetic variation between the birds in the Interior Savannah zone. Although the Coastal Savannah and Forest ecotypes seemed close, they are still genetically diverse and are different from the Interior Savannah ecotype. These results could inform conservation strategies and policies to boost local chicken production in Ghana.

Recommendations

Further studies on the origin of the birds that clustered separately in the PCA should be carried out. Conservation strategies should be put in place to reduce the imminent loss of genetic diversity of Coastal Savannah and Forest zone birds and its possible effect on the Interior Savannah birds.

Acknowledgement

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